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VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

1976 LITERATURE ABSTRACTS

U.S. ENVIRONMENTAL PROTECTION AGENCY
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VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

Editor: Gerald Berg, Ph.D.
Editorial Assistant: F. Dianne White

1976

BIOLOGICAL METHODS BRANCH
ENVIRONMENTAL MONITORING AND SUPPORT LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
ENVIRONMENTAL RESEARCH CENTER
U.S. ENVIRONMENTAL PROTECTION AGENCY
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AUTHOR AND SUBJECT INDEXES

VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS now contains an *Author Index* and a *Subject Index*. Both listings may be found at the end of this volume. The Greek letters that appear above each abstract are the coding for the *Subject Index*. An explanation for their meanings is given on the first page of that index.

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1976

VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

$\xi \pi \delta \theta$

Aizen, M.S., Pille, E.R. (1976). *Role of Food Products in the Spread of Viral Infections.* **ZH MIKROBIOL EPIDEMIOL IMMUNOBIOL, 0(3)**:12-7. **Russian.**

Outbreaks of shellfish-borne hepatitis A, and outbreaks of other food-borne viral diseases in which water played some role are briefly discussed within a review of food-borne viral diseases.

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Akin, E.W., Hill, W.F., Jr., Cline, G.B., Benton, W.H. (1976). *The Loss of Poliovirus 1 Infectivity in Marine Waters.* **WATER RES, 10(1)**:59-63.

Three logs of infectivity of poliovirus 1 were lost in 5 to 6 days at 24 C in raw, filter-sterilized, and autoclaved marine waters. This loss of infectivity apparently did not result from aggregation of viruses or from adsorption of viruses to containers. Two-component curves often occurred with the loss of virus; a resistant population in the seed virus that might account for such curves was not found.

Loss of infectivity occurred when the virus was suspended in artificial seawater of 1, 10, and 20 g/kg salinity. No explanation for this loss, other than inactivation of the virions, was found. The specific component(s) of marine water responsible for the inactivation was not identified.

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Albano, A., De Donato, S. (1974). *A Simple Procedure for Detecting Viruses in Sewage.* **BOLL IST SIER, 53(1)**:16-23. **Italian.**

A procedure that consisted of passing settled sewage through filter paper and eluting adsorbed and trapped viruses from the triturated paper with 10% calf serum in borate buffer (pH 9) was about equal in effectiveness to the gauze pad procedure and considerably superior to the polyelectrolyte procedure for recovering viruses from sewage.

ν

Alexandre, D., Gevaudan, P., Charrel, J., Gulian, C., Mallet, M.N., Blancard, A. (1975). *Study of the Survival of Microorganisms in Wastewaters During Purification by Physico-Chemical Treatment.* **TECH EAU ASSAINISSEMENT, 345**:31-8. **French.**

From 37 to 94% of seeded poliovirus 3 was removed from sewage by flocculation with alum $Al_2(SO_4)_3$ at pH 9. Flocculation at pH 11.5 removed 99.87% of the seeded virus or more. The quantity of viruses removed remained unchanged when carbon was added to the flocced sewage.

The alum concentration in all experiments was 200 gm/m^3. The pH levels were achieved with the addition of lime [$Ca(OH)_2$]. Activated carbon when used was applied in a concentration of 150 gm/m^3 at pH 9 and at a concentration of 100 gm/m^3 at pH 11.5.

ξ χ κ

Bachmann, P.A. *Epidemiological and Epizootiological Significance of Pathogenic Microorganisms in Surface Water and Sewage.* **In "Munich's Contributions to Sewage, Fishery and Stream Biology, Vol. 26, Water for Land Reclamation Areas." Oldenbourg Verlag, Munich, West Germany** (1975), 155-65. **German.**

The transmission of viral diseases by water is reviewed in relation to the frequency and types of viruses found in water, the survival of viruses in surface waters and sewages, and what constitutes the minimal infective dose for viruses.

λ

Belfort, G., Rotem, Y., Katzenelson, E. (1976). *Virus Concentration Using Hollow Fiber Membranes. II.* **WATER RES, 10(4)**:279-84.

Poliovirus 1 was concentrated in asymmetric polysulphone hollow fiber membranes. Average recovery efficiencies of 61 and 77% were achieved from 5- and 50-liter quantities of deionized water, respectively, and an average recovery efficiency of 52% was achieved from 50 liters of tap water. From 22 to 45% of the recoveries were obtained from filter backwash.

In earlier experiments with symmetric semi-dense cellulose acetate hollow fibers, an average of 84% of the poliovirus was recovered from 5 liters of deionized water, 36% from filter backwash.

Effectiveness of the membranes was unaffected by the initial virus concentrations which spanned a five-log range.

The asymmetric membranes exhibited higher virus rejections before they were backwashed, a higher water permeation coefficient, and suffered less penetration of virus into the membranes than the symmetric membranes did.

Bell, R.G. (1976). *The Limitation of the Ratio of Fecal Coliforms to Total Coliphage as a Water Pollution Index.* **WATER RES, 10(8)**:745-8.

The ratios of fecal coliforms (MPN) to coliphage (of *Escherichia coli* B, ATCC 11303-1) in raw sewage, sewage lagoon effluent, and in river water were 87:1, 4.2:1, and 0.15:1, respectively. The ratio of fecal coliforms to coliphage in stored raw sewage decreased from 87:1 to about 1:1 within 7 days at 20 C and within 28 days at 4 C.

The ratio of fecal coliforms to coliphage is not a reliable index of fecal pollution because the ratio is affected by environmental conditions.

Berry, S.A., Noton, B.G. (1976). *Survival of Bacteriophages in Seawater.* **WATER RES, 10(4)**:323-7.

In laboratory studies at 4 C and 12 C, coliphage T2 titers were stable in artificial seawater for 48 days. In unpolluted seawater, about 90% of the phage was inactivated in 48 days at 4 C, and about 95% of the phage was inactivated in 48 days at 12 C. In heavily polluted seawater, about 99% of the phage was inactivated in 48 days at 4 C and more than 99.99% was inactivated in 48 days at 12C. In 14 days, dialysed in tubing against normal seawater at 12 C, more than 99.99999% of the phage was inactivated in polluted seawater, and more than 99.9% of the phage was inactivated in normal seawater.

The phage survived longer in centrifuged, membrane-filtered, or autoclaved seawater than in natural seawater, probably because organic and microbial material were removed from or destroyed in the centrifuged, membrane filtered, and autoclaved waters.

The phage, in artifical seawater or in polluted seawater (in dialysis bags), was inactivated more rapidly in shallow (0-8.7 feet) than in deep (4.6-15 feet) seawater, possibly the result of exposure to sunlight.

Coliphage T2 survived longer in seawater in the laboratory than in seawater (in dialysis tubes) in a bay.

σ

Bitton, G., Masterson, N., Gifford, G.E. (1976). *Effect of a Secondary Treated Effluent on the Movement of Viruses Through a Cypress Dome Soil.* **J ENVIRON QUAL, 5(4)**:370-5.

The adsorption of coliphage T2 and poliovirus 1 onto sandy cyprus dome soil in columns was substantially lower in soil treated with secondary effluent than in soil treated with tap water. The secondary effluent also could desorb viruses from soil particles.

It appears that organic materials in waste water effluents may interfere with the interaction between viruses and soil particles.

ν

Bitton, G., Pancorbo, O., Gifford, G.E. (1976). *Factors Affecting the Adsorption of Polio Virus to Magnetite in Water and Wastewater.* **WATER RES, 10(11)**:973-80.

The adsorption of poliovirus 1 to magnetite was enhanced by cations and conformed to the Freundlich isotherm.

At pH levels of 5 to 9, greater than 99% of the virus adsorbed to the magnetite when the concentration of magnetite exceeded 300 mg/liter and the salt concentrations were 60 mg/liter or greater.

ζ

Bondarenko, V.I., Grigoryeva, L.V. (1975). *Isolation of Enteroviruses from the Surfaces of Vegetables and Fruit.* **MICROBIOL ZH, 37(2)**:244-7. **Ukrainian.**

Enteroviruses were recovered from the surfaces of vegetables and fruits grown in fields irrigated with sewage.

Echoviruses 7, 8, 11, and 19, coxsackieviruses A9, B3, and B4 and several unidentified viruses were recovered.

Eighteen percent of 82 carrots and 12% of 67 potatoes tested yielded viruses. Lower recoveries were obtained in tomatoes, radishes, fruits, berries, lettuce, and cucumbers. Viruses were not recovered from onions, parsley, cabbage, or dill suggesting possible antiviral activity of these vegetables.

The viruses were recovered from anion exchange resin concentrated tap water washings of the surfaces of the fruits and vegetables.

ξ σ

Bouwer, H. (1976). *Use of the Earth's Crust for Treatment or Storage of Sewage Effluent and Other Waste Fluids.* **CRIT REV ENVIRON CONTR, 6(2)**:111-30.

In a review of the treatment of sewage and the disposal of effluent on land and by deep well injection, the movement and survival of viruses in soil and the problems associated with spreading and spraying effluents on the land are discussed.

ε

Brown, E.R., Dolowy, W.C., Sinclair, T., Keith, L., Greenberg, S., Hazdra, J.J., Beamer, P., Callaghan, O. (1976). *Enhancement of Lymphosarcoma Transmission in* Esox lucius *and its Epidemiologic Relationship to Pollution.* **BIBL HAEMATOL, (43)**:245-51.

The Mulcahy lymphosarcoma was transmitted by an apparent cell-free homogenate giving credence to a viral etiology for this tumor. However, Millipore-filtered material failed to produce tumors in young fish. Fish size, the site of inoculation, temperature of the water, and age of fish recipients affected the rapidity of growth of tumor transplants.

Epidemiologically, more and more evidence links organic chemical pollution to the frequency of tumors. That human enteric viruses have been detected in fish indicates the seriousness of these environmental problems.

μ

Buras, N. (1976). *Concentration of Enteric Viruses in Wastewater and Effluent: A Two Year Survey.* **WATER RES, 10(4)**:295-8.

Enteric viruses were recovered throughout the year during a two-year survey of the wastewater and effluent of the Haifa (Israel) sewage treatment plant. The numbers of enteric viruses in the wastewater and effluent fluctuated with the seasons and were usually lowest during the winter. The greatest numbers of viruses were recovered between the months of April and September. A peak of 106 x 10^3 PFU/100 ml occurred in wastewater during one July, and a peak of 94 x 10^3 PFU/100 ml occurred in effluent during one August.

δ

Carlson, S. (1974). *Earlier Detection of Virus Epidemics Through Sewage Investigations.* **BUNDESGESUNDHBL, 17(25-26)**:403-5. **German.**

Viruses are present in all sewage effluents. Most of the viruses found are the same as those circulating in the population and excreted with the feces. From the distribution and concentration of different virus types in sewage, epidemiological inferences may be drawn.

γ

Carlson, S., Hässelbarth, U., Sohn, F.W. (1976). *Studies on Virus Inactivation by Chlorine During Water Disinfection.* **ZBL BAKT HYG, 162(3-4)**:320-9. **German.**

The ability of free chlorine (HOCl and/or OCl^-) to inactivate viruses is better indicated by the oxidation-reduction potential (ORP) of the free chlorine than by its concentration. A greater ORP and a longer period of contact is needed to inactivate viruses than to inactivate bacteria.

To insure inactivation of polioviruses in water that contains organic material, an ORP of +750 mV (0.3-0.6 mg/liter of free chlorine) must be maintained for 15 to 30 minutes.

Adenoviruses and polioviruses are almost equally resistant to inactivation by chlorine.

ξ γ

Carlson, S., Hässelbarth, U., Sohn, F.W. (1976). *Virus Inactivation by Chlorine—Literature Review.* **ZBL BAKT HYG, 248**:193-215. **German.**

The inactivation of viruses by chlorine is extensively reviewed.

μ

Caroli, G., Avio, C.M. (1975). *Isolation of Mycobacteriophages from Surface Water.* **ANN SCLAVO, 17(4)**:568-70.

Mycobacteriophages were recovered from 5 of 15 water samples taken from canals surrounding the town of Pisa. Eleven of the samples contained atypical mycobacteria.

ξ ν

Cillié, G.G. *Current Technology and Advances in True Re-Use of Effluents.* **In "Radiation for a Clean Environment." Proceedings of the International Symposium on the Use of High-Level Radiation in Wastewater Treatment—Status and Prospects, Munich, March 1975. International Atomic Energy Agency, Vienna, Austria** (1975), 29-43.

The removal of viruses from sewage by treatment processes is briefly discussed within a review of renovation and reuse of sewage.

τ ρ

Cliver, D.O. (1975). *Virus Association with Wastewater Solids.* **ENVIRON LETTERS, 10(3)**:215-23.

Reoviruses and at least five different enteroviruses were recovered from the solids of an urban wastewater treatment plant. Viruses were recovered from sludge digested anaerobically at 30 to 32 C and from grit.

Until reliable means for inactivating viruses in sludge and grit have been developed and implemented, great care must be taken in disposing of these solids.

ρ

Cliver, D.O. *Surface Application of Municipal Sludges.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber, Center for Environmental Programs, University of Florida, Gainesville** (1976), 77-81.

Viruses in wastewater tend to sediment with the sludges that are formed in treatment. Sludges that contain viable viruses

should be disposed to soil in a way that precludes run-off. Once sludges have been properly disposed of at a properly selected site, the viruses present in the sludges probably represent relatively little risk to public health.

Given the possibility of human error, however, a community that cannot exert direct control over the surface application of its sludges is probably well-advised to modify its processes to insure that all viruses are inactivated before the sludges leave the treatment plants.

Couch, J.A. (1976). *Attempts to Increase* Baculovirus *Prevalence in Shrimp by Chemical Exposure.* **PROG EXP TUMOR RES, 20**:304-14.

In laboratory studies, pink shrimp *(Penaeus duorarum)* harvested from areas with various enzootic levels of natural *Baculovirus* infection were exposed to low levels of Aeroclor 1254, a polychlorinated biphenyl (PCB), Mirex, cadmium, and methoxychlor.

No consistent pattern of increase in prevalence of viruses and no indication of tumor induction was detected.

Couch, J.A., Summers, M.D., Courtney, L. *Environmental Significance of* Baculovirus *Infections in Estuarine and Marine Shrimp.* **In "Pathobiology of Invertebrate Vectors of Disease." ANN NY ACAD SCI, 266, New York Academy of Sciences, New York** (1975), 528-36.

A *Baculovirus* enzootic in populations of penaeid shrimps in the northern Gulf of Mexico has been discovered. The rod-shaped virus, both free and occluded, was detected in polyhedral inclusion bodies in the nuclei of host hepatopancreatic cells. The virus produced striking cytopathologic effects, but induced no gross signs.

Latent infections have been detected in from 0 to 50% of the samplings of pink shrimps taken since 1971. The virus has not yet been grown in established insect cell lines.

The virus was recovered from shrimps taken from waters of Apalachee Bay, Port St. Joe, and Pensacola, all in Florida. In the laboratory, the incidence of *Baculovirus* infections in shrimps was increased by maintaining the shrimps in large numbers in small aquariums.

The effect that the *Baculovirus* has on populations of shrimps in nature, whether pollutant chemicals in coastal waters affect the virus in shrimps, and whether the occurrence of this *Baculovirus* in a crustacean relates to the development of insect *Baculovirus* biopesticides are matters currently under investigation.

γ

Cramer, W.N., Kawata, K., Krusé, C.W. (1976). *Chlorination and Iodination of Poliovirus and f2.* **J AMER WATER WORKS ASSOC, 48(1)**:61-76.

Poliovirus 3 (Leon) was slightly more sensitive to HOCl and OCl^- and considerably more sensitive to chloramines, particularly dichloramine, than coliphage f2.

Under dynamic test conditions, in which the disinfectant was mixed rapidly into the sterilized sewage that contained the virus, coliphage f2 and poliovirus 3 were equally and highly sensitive to iodine at pH levels of 6 and 10. At pH 4, both viruses, especially the coliphage, were destroyed more slowly.

In prereacted studies, in which the disinfectant was mixed with the sterilized sewage before the virus was added, both viruses were rapidly inactivated by iodine at pH 6 (when an iodine residual persisted), but were unaffected at pH 10 (when an iodine residual was not detected).

In this study, coliphage f2 was equally or more resistant than poliovirus 3 to chlorine and iodine.

At pH levels and KI concentrations that favored iodination of tyrosine and histidine, both viruses were inactivated rapidly indicating that the mode of action of iodine was similar with both viruses. At high hydrogen ion concentrations, where the iodination of tyrosine and histidine is inhibited, both viruses were inactivated slowly by iodine.

ξδθ

Craun, G.F., McCabe, L.J., Hughes, J.M. (1976). *Waterborne Disease Outbreaks in the US—1971-1974.* **J AMER WATER WORKS ASSN, 68(8)**:4106-10.

Thirteen outbreaks of waterborne hepatitis A, in which 351 people became ill, occurred from 1971 to 1974.

Epidemiologically, hepatitis A has been implicated in 66 outbreaks of waterborne disease since 1946. Twenty-two of these outbreaks involved municipal systems, three with inadequate or interrupted disinfection, five that used contaminated, untreated surface or ground waters, and eleven that were contaminated by cross connections or back-siphonage.

Forty-six outbreaks of gastroenteritis of unknown etiology also occurred from 1971 to 1974. Almost 8,000 cases of illness resulted.

Waterborne giardiasis, shigellosis, salmonellosis, typhoid fever, and chemical poisonings that occurred from 1971 to 1974 are also noted.

μ

Dartevelle, Z., Desmet, L. (1975). *Shigella Research in the Sea and in an Estuary. Part I. Frequency of Bacteriophages in Polluted Water.* **ANN MICROBIOL (Paris), 126B(1)**:95-7. **French.**

This paper was listed in the 1975 edition of these abstracts. A translation was not then available.

Shigella phages and coliphages were recovered from sewage-polluted waters of the Gulf of Trieste.

μ

Derbyshire, J.B. (1976). *Fate of Animal Viruses in Effluent from Liquid Farm Wastes.* **J MILK FOOD TECHN, 39(3)**:214-7.

Seventeen of 22 samples of liquid manure from a swine fattening house yielded enteroviruses, adenoviruses, and coronaviruses. An enterovirus was recovered from one of six samples of waste from a swine farrowing house, but no viruses were recovered from 18 samples of liquid cattle manure from a dairy farm.

Swine enteroviruses were recovered from surface soil samples collected up to eight days after liquid manure had been spread on agricultural land. Swine enteroviruses were recovered also from 2 of 26 samples of surface run-off collected from sites at which liquid pig manure had been spread routinely on agricultural land. A swine enterovirus was recovered from one of 33 samples of surface water collected in areas in which liquid pig manure had been spread routinely on farm land. No viruses were recovered from any of 36 samples of ground water collected from such areas.

Field and laboratory experiments indicate that enteroviruses are more rapidly inactivated in aerated liquid manure than in untreated manure.

πδθ

Dienstag, J.L., Gust, I.D., Lucas, C.R., Wong, D., Purcell, R.H. (1976). *Mussel-Associated Viral Hepatitis, Type-A: Serological Confirmation.* **LANCET, 1(7959)**:561-4.

An epidemiological investigation incriminated incompletely cooked mussels *(Mytilus edulis)* as the vehicle of hepatitis A transmission in seven members of a family of 14 who developed hepatitis one month after a family outing.

The etiological role of hepatitis A virus was serologically confirmed by rises in serum-antibody titers to hepatitis A antigen in immune adherence hemagglutination tests.

ν

Dor, I., Schechter, H., Shuval, H.I. (1976). *Biological and Chemical Succession in Nahal Soreq: A Free-Flowing Wastewater Stream.* **J APPL ECOL, 13(2)**:475-89.

About half of the 21,000 m^3 of undiluted raw sewage that enters the Nahal Soreq (a free-flowing wastewater stream) in Israel daily is lost by seepage (82%) and evaporation (18%). The remainder of the sewage undergoes progressive purification in the river bed.

In a recent study during the dry season, the concentration of enteric bacteria was reduced by 99% and the concentration of en-

teric viruses by 95% after 45 km of river flow at a flow rate of about 1 km/hour. Concurrently, the BOD was reduced by 97%, the COD by 90%, and the total suspended solids by 91%.

The purifying capability of the river did not diminish during the winter except during storms.

σ

Duboise, S.M., Moore, B.E., Sagik, B.P. *Surface Application of Municipal Effluents.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 69-76.

In laboratory studies, poliovirus 2 (Chat) moved for considerable distances through non-sterile soil core samples after periods of simulated rainfall. In these studies, periods of simulated rainfall were alternated with periods of application of dechlorinated activated sludge effluents.

σ

Duboise, S.M., Moore, B.E., Sagik, B.P. (1976). *Poliovirus Survival and Movement in a Sandy Forest Soil.* **APPL ENVIRON MICROBIOL, 31(4)**:536-43.

Applications of water and activated sludge effluent (to simulate cycles of rainfall and effluent application) onto nonsterile sandy forest soil produced ionic gradients that affected movement through the soil of poliovirus 1 that had been seeded into the effluent. These studies indicated that poliovirus in effluents applied to soil moved considerable distances through this soil after rainfalls.

The capability of the virus to migrate through the soil at 4 C and 20 C remained unchanged for at least 84 days.

ξ δ ο

DuPont, H.L. *"Culture-Negative" Acute Diarrhea.* **In "Gastro-Intestinal Emergencies," edited by H.R. Clearfield and V.P. Dinoso, Jr. Grune and Stratton, New York** (1976), 269-74.

The association of rotaviruses with more than half of the infantile gastroenteritis that occurs worldwide is noted within a concise review of the microbial etiology, epidemiology, and clinical concerns in diarrheal disease.

ξ δ θ

Earampamoorthy, S., Koff, R.S. (1975). *Health Hazards of Bivalve-Mollusk Ingestion.* **ANN INTERN MED, 83(1)**:107-10.

Bivalve mollusks (oysters, clams, and mussels) filter large quantities of water unselectively and thereby concentrate a variety of aquatic contaminants pathogenic for man within edible shellfish viscera.

The recognized bacterial diseases associated with ingestion of contaminated bivalves include typhoid fever, cholera, and *Vibrio parahemolyticus* gastroenteritis. The major known shellfish-associated viral diseases are hepatitis A and possibly viral gastroenteritis.

The ingestion of bivalves that have fed on the toxic dinoflagellates that produce red tides is responsible for paralytic shellfish poisoning. But, outbreaks of airborne respiratory irritation in populations exposed to red tides may be the most common public health problem associated with red tides.

The hazards to human health that result from exposure of bivalves to industrial, agricultural, and oil pollution in coastal waters, and the hazards from improper handling of bacterially-contaminated mollusks remain to be defined.

v

Engelbrecht, R.S., Amirhor, P. *Disposal of Municipal Solid Waste by Sanitary Landfill.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 59-67.

Disposable diapers, other soiled hygiene products, dog and cat litter, and household products that contact human body openings are sources of viruses in municipal solid wastes. Viruses may be recovered from landfills and leachates.

Viruses adsorb to solids and other substances in landfills and are destroyed in leachates by heat (temperatures may reach 55 to 60 C for short periods), generated by aerobic digestion in young landfills when moisture content is sufficient (40 to 60%), and by toxic substances that occur in leachates in aging landfills (75 to 215 days).

Some evidence exists which suggests that low molecular weight fatty acids and heavy metals (iron and zinc) may be responsible for some leachate toxicity.

γ ρ

Epp, C. *Experience with a Pilot Plant for the Irradiation of Sewage Sludge. Experiments on the Inactivation of Viruses in Sewage Sludge After Radiation Treatment.* **In "Radiation for a Clean Environment." Proceedings of the International Symposium on the Use of High-Level Radiation in Wastewater Treatment—Status and Prospects, Munich, March 1975. International Atomic Energy Agency, Vienna, Austria** (1975), 485-90.

Viruses were detected in eight of 33 samples of sewage sludge. After exposure to 300 krad from a ^{60}Co source, viruses were recovered from only two of the 33 samples. Approximately similar recoveries were attained with poliovirus 1-seeded sludge.

When poliovirus 1 was irradiated similarly in ampules suspended in sludge, about 90% of the virus was inactivated.

γ ρ

Epp C. *Virological Studies on the Ozone Apparatus Manufactured by the Demag Company at the Grosslappan Experimental Sewage Treatment Facility.* **In "Munich's Contributions to Sewage, Fishery and Stream Biology, Vol. 26, Water for Land Reclamation Areas." Oldenbourg Verlag, Munich, W. Germany** (1975), 191-4. **German.**

Fourteen grams of ozone/m^3 of activated sludge effluent destroyed seeded poliovirus in 12 minutes. Eight to nine grams of ozone/m^3 of activated sludge effluent did not destroy all of the poliovirus in 24 minutes.

α

Fannin, K.F., Spendlove, J.C., Cochran, K.W., Gannon, J.J. (1976). *Airborne Coliphages from Wastewater Treatment Facilities.* **APPL ENVIRON MICROBIOL, 31(5)**:705-10.

The mean levels of coliphages in the airborne emissions of trickling-filter beds and activated sludge treatment plants (that contained phage) were 2.84×10^{-1} and 3.02×10^{-1} MPN/m^3, respectively. The coliphage levels in the sewage were about 5×10^5 to 3×10^6 PFU/liter.

Wind velocity and temperature did not affect the airborne concentration of coliphages, but airborne coliphage concentrations increased as humidity increased.

Darkness may have also favored survival of airborne coliphages.

All air samples were taken 2 to 15 meters from the edge of the plants at a height of 1.5 meters.

π

Farley, C.A. (1976). *Ultrastructural Observations on Epizootic Neoplasia and Lytic Virus Infection in Bivalve Mollusks.* **PROG EXP TUMOR RES, 20**:283-94.

Epizootic neoplasia occurs in marine bivalve mollusks.

Epidemic sarcomas occurred in oysters and mussels from Oregon in incidences of 12 to 40% in the fall, winter, and spring.

A recent epizootic in clams (*Macoma balthica*) from Maryland exhibited the same epizootiologic seasonality and occurred in a localized geographic area. Lesions developed in the gills and invaded tissues throughout the animal. Ultrastructural evidence indicated epithelial origin of the neoplastic cells. Degenerative and preneoplastic changes in the epithelium were also evident.

A virus morphologically similar to papillomavirus has been discovered that replicates in germ cells of oysters (*Crassostrea virginica*).

γ

Farooq, S., Chian, E.S.K. (1976). *Discussion—Inactivation of Poliovirus in Water by Ozonation,* **J WATER POLLUT CONTRL FED, 48(3)**:593-8.

This paper is a discussion of a study by **Majumdar, Ceckler, and Sproul (Majumdar, S.B., Ceckler, W.H., Sproul, O.J.** (1973). *Inactivation of Poliovirus in Water by Ozonation,* **J WATER POLLUT CONTRL FED, 45(12)**:2433-43; **Majumdar, S.B., Ceckler, W.H., Sproul O.J.** (1974). *Communication—Inactivation of Poliovirus in Water by Ozonation,* **J WATER POLLUT CONTRL FED, 46(8)**:2048-53) in which the data on the kinetics of the inactivation of poliovirus 1 by ozone are reanalyzed.

See 1973 and 1974 Literature Abstracts.

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Farrah, S.R., Gerba, C.P., Wallis, C., Melnick, J.L. (1976). *Concentration of Viruses from Large Volumes of Tap Water Using Pleated Membrane Filters.* **APPL ENVIRON MICROBIOL, 31(2)**:221-6.

Poliovirus 1 was recovered from seeded tap water (pH adjusted to 3.5 and $AlCl_3$ to 0.0005 M final) by adsorbing the virus onto a 10-inch (25.4 cm) fiberglass depth cartridge and a 10-inch pleated epoxy-fiberglass filter arranged in series in a Wallis-Melnick concentrator. Flow rates up to 37.8 liters/minute were achieved.

Adsorbed viruses were eluted from the filters with glycine buffer (pH 10.5), the eluate was reconcentrated by an aluminum flocculation process, and the viruses were eluted from the aluminum floc with glycine buffer (pH 11.5).

With this procedure, an average of 40 to 50% of the viruses in 1,900 liters (500 gallons) of tap water were recovered in a period of three hours.

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Farrah, S.R., Goyal, S.M., Gerba, C.P., Wallis, C., Shaffer, P.T.B. (1976). *Characteristics of Humic Acid and Organic Compounds Concentrated from Tapwater Using the Aquella Virus Concentrator.* **WATER RES, 10(10)**:897-901.

Humic acids and other organic compounds in eluates from filters used in processing large volumes of tap water with the Wallis-Melnick virus concentrator adsorbed to membrane filters at low pH, eluted from membrane filters at high pH, interfered with virus adsorption to membrane filters, and formed flocs at low pH. The humic acids were removed from the eluates by anion-exchange resins.

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Farrah, S., Wallis, C., Shaffer, P.T.B., Melnick, J.L. (1976). *Reconcentration of Poliovirus from Sewage.* **APPL ENVIRON MICROBIOL, 32(5)**:653-8.

Certain soluble components in sewage adsorb on virus adsorbent filters and are removed along with the viruses by elutants. Upon acidification of eluates to reconcentrate the viruses on

smaller membrane surfaces, flocs form that interfere with the reconcentration process. The interfering sewage components may be removed from eluates by activated carbon and ion-exchange resins.

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Fattal, B., Katzenelson, E. (1976). *Evaluation of Gauze Pad Method to Recover Viruses from Water.* **WATER RES, 10(12)**:1135-40.

In field studies, the gauze pad method was more effective for detecting enteroviruses in a sewage stream than two-liter volume grab samples concentrated by the phase separation method.

In laboratory experiments, the recovery efficiency of the gauze pad method for concentrating viruses from tap water was very low and depended upon sample volume—the larger the volume the lower the efficiency.

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Floyd, R., Johnson, J.D., Sharp, D.G. (1976). *Inactivation by Bromine of Single Poliovirus Particles in Water.* **APPL ENVIRON MICROBIOL, 31(2)**:298-303.

Quantitative electron microscopy showed that in Freon-extracted poliovirus 1 preparations velocity banded in a sucrose gradient, more than 95% of the virions were present as single particles.

At 2 C, these well-dispersed virions were inactivated in rapidly flowing 2.2 μM bromine at pH 7 at the rate of one $\log_{10}$ unit/10 seconds.

The rate of inactivation of the virions increased with increasing temperature. At 10 C and 30 C, the rate of inactivation increased approximately linearly with increasing bromine concentration. At 2 C, a linear relationship did not occur.

ξ θ δ

Fox, J.P. *Human-Associated Viruses in Water.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976) 39-49.

Contaminated water may be a vehicle for transmitting viruses to man when the water is used for drinking, washing eating utensils, dishes, and food to be consumed without cooking, brushing teeth, bathing, swimming, and irrigation of vegetables. Shellfish harvested from sewage-polluted waters may also be a vehicle for transmitting viruses to man.

Feces and urine are the most important sources of human viruses in waters. Enteroviruses and adenoviruses, hepatitis A virus, and the viruses of acute infectious non-bacterial gastroenteritis are among those most likely to be transmitted by water.

In developed countries, transmission of these agents through drinking water supplies is likely only if breaks occur in the treat-

ment procedures. In undeveloped countries, waterborne spread is presumedly extensive and may constitute safe natural immunization when it occurs early in life.

ξ β

Freytag, B. *Hygienic Aspects of Swimming in Lakes.* **In "Munich's Contributions to Sewage, Fishery and Stream Biology, Vol. 26, Water for Land Reclamation Areas." Oldenbourg Verlag, Munich, West Germany** (1975), 111-12. **German.**

The significance of viruses in bathing waters is evaluated within a broad discussion of the sanitation of swimming lakes.

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Gilbert, R.G., Gerba, C.P., Rice, R.C., Bouwer, H., Wallis C., Melnick, J.L. (1976). *Virus and Bacteria Removal from Wastewater by Land Treatment.* **APPL ENVIRON MICROBIOL, 32(3)**:333-8.

Neither viruses nor *Salmonella* were detected in renovated waters from four wells at the Flushing Meadows Wastewater Renovation Project near Phoenix, Arizona. The waters were assayed bimonthly in 1974 during flood periods.

Filtration of wastewater through nine meters of soil decreased the numbers of fecal coliforms, fecal streptococci, and total bacteria in the renovated well waters by about 99.9%.

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Gilbert, R.G., Rice, R.C., Bouwer, H., Gerba, C.P., Wallis, C., Melnick, J.L. (1976). *Wastewater Renovation and Reuse: Virus Removal by Soil Filtration.* **SCIENCE, 192(6)**:1004-5.

Effluent from an activated sludge sewage treatment plant at the Flushing Meadows Wastewater Renovation Project near Phoenix, Arizona, sampled bimonthly, yielded an average of 2,118 virus infective units/100 liters (range 158 to 7,475 infective units/100 liters).

Viruses were not detected in wells at depths of 6 to 9 meters in sand infiltration basins during the second seven days of 14-day effluent charge periods. The sand appeared to remove at least 99.99% of the viruses from the effluent.

The viruses were received by membrane adsorption-elution virus concentrator technics.

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Globa, L.I., Rotmistrov, M.N., Bember, V.E., Grebenyuk, V.D., Gvozdyak, P.I. (1975). *Freeing Water from Viruses by Electro Dialysis.* **ELEKTRON OBRAB NATER, 4**:57-9. **Translation presently not available. Russian.**

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Goldfield, M. *Epidemiological Indicators for Transmission of Viruses by Water.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 70-85.

Ample evidence indicates that too many people in the United States too often are provided with unsafe water supplies. Although potable public water supplies may be treated in inadequate facilities operated by inadequately trained personnel, dispensed through faulty distribution systems and woefully monitored as to water quality, the situation with respect to semi-public water supplies is even worse.

Generally, the responsibility for inspecting semi-public supplies, where they are inspected with any regularity or frequency at all, is left to locally employed sanitarians who may be inadequately trained, poorly motivated, virtually unsupervised and subject to strong local political pressures to overlook defects. In the United States, most semi-public supplies are unchlorinated and when tested at all, are frequently tested in laboratories of inadequate competence.

The general public, and even large segments of the medical community—have a grossly distorted impression of surveillance of disease in the United States. Over the years, they have been led to believe that some system exists for recognizing disease outbreaks that provides reasonable assurance that significant clusters of illness will be recognized, studied, and handled appropriately by public health authorities. To them, the absence of reported outbreaks provides reassuring evidence of a safe and healthful environment. Unfortunately, this is pure myth. Even huge waves of febril respiratory disease, gastrointestinal illness, measles, or german measles can go completely undetected unless arduous efforts are made to develop surveillance programs. In New Jersey, outbreaks of a disease as dramatic in its consequences as eastern encephalitis went completely undetected until a study was mounted to search for its occurrence.

Hepatitis A virus is the single virus thus far associated with waterborne outbreaks, probably because it frequently produces overt disease in susceptible populations, and because the overt disease produced is relatively easily recognized as an entity. Other enteroviruses, however, may eventually be shown to be far more commonly transmitted by drinking water than hepatitis A virus is.

$\xi\ \theta$

Grabow, W.O.K. (1976). *Progress in Studies on the Type A (Infectious) Hepatitis Virus in Water.* **WATER SA, 2(1)**:20-4.

The nature, epidemiology, clinical significance, and the transmission by water of hepatitis A and B viruses are reviewed.

Data on recent findings which indicate that lesser bushbabies *(Galago senegalensis moholi)* may be susceptible to hepatitis A virus are presented.

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Gude, G. *The Legislative Concern for Research on Viruses in Waste and Potable Waters.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 27-35.

Against a background of current legislative efforts, the history of the treatment of sewage, and the control of waterborne infectious diseases throughout the world, Congressman Gilbert Gude discusses the oncoming needs for water renovation and for methods to assure that renovated waters will be free of viruses.

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Guy, M.D., McIver, J.D. Lewis, M.J. (1976). *The Application of the Foam Fractionation Process to the Removal of Viruses. Part I. The Production of A Mathematical Model to Predict the Efficiency of Virus Removal.* **WATER RES, 10(8)**:737-9.

Removal of coliphage MS2 by Arquad T50 (a cationic surfactant composed of a blend of alkyl quaternary ammonium chlorides) in a laboratory scale foam fractionation plant was brought about by adsorption of the virus to the surfactant and by the physical removal of free virus particles entrapped in interstitial liquid.

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Guy, M.D., McIver, J.D., Lewis, M.J. (1976). *The Application of the Foam Fractionation Process to the Removal of Viruses. Part III. An Investigation of the Toxicity of the Surfactant.* **WATER RES, 10(8)**:742-4.

The cationic surfactant Arquad T50 (a blend of alkyl quaternary ammonium chlorides) was toxic to coliphage MS2.

An attenuated poliovirus, coxsackievirus B3, and echovirus 11 were relatively unaffected by the surfactant.

δ μ

Hattingh, W.H.J., Nupen, E.M. (1976). *Health Aspects of Potable Water Supplies.* **WATER SA, 2(1)**:33-46.

In the first two years of a ten-year research program to assess the chemical and microbiological quality of potable reclaimed effluents and other potable waters, the quality of reclaimed waters was at least as good as that of treated surface waters.

To date, viruses have not been detected in reclaimed water.

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Hill, B.J. *Properties of a Virus Isolated from Bi-Valve Mollusc* Tellina tenuis *(Da Costa).* **In "Wildlife Diseases," edited by L.A. Page. Plenum Press, New York, New York** (1976), 445-52.

A virus was recovered from a marine bivalve mollusc *(Tellina tenuis)* with a disease of the digestive gland. Morphologically, the virus resembled the fish pathogen infectious pancreatic necrosis (IPN) virus. The two viruses did not cross react in neutralization

tests, but an antigenic relationship between the two viruses was demonstrated in fluorescent antibody tests.

The newly recovered virus contained RNA in its nucleic acid, had a growth temperature optimum near 15 C, was resistant to lipid solvents, was stable at pH 3, at -20 C in 50% glycerol, and at -20 C and -70 C in the frozen state.

The virus infected *Tellina tenuis* and also the Japanese oyster *(Crassostrea gigas)*.

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Hill, W.F., Jr., Jakubowski, W., Akin, E.W., Clarke, N.A. (1976). *Detection of Virus in Water: Sensitivity of the Tentative Standard Method for Drinking Water.* **APPL ENVIRON MICROBIOL, 31(2)**:254-61.

The sensitivities of nitrocellulose membrane filters, epoxy-fiberglass-asbestos filters, yarn-wound fiber glass depth filters, and epoxy-fiber glass filter tubes for detecting small quantities of viruses in large quantities of drinking water were investigated. The test procedure was that proposed as a tentative standard method in the fourteenth edition of Standard Methods for the Examination of Water and Wastewater (APHA, AWWA, WPCF, Washington, D.C., 1976). Viruses were adsorbed to the filter media at pH 3.5 and eluted with glycine buffer, pH 11.5.

In 120 tests with poliovirus 1, the efficiencies of virus recoveries ranged from 28 to 42%; the average efficiency was 35%. In 44 tests with virus input levels of 15 to 35 PFU/1,900 liters of water sampled, the poliovirus was detected 95% of the time. In 76 tests with virus input levels of 10 PFU or less/1,900 liters, the virus was detected 66% of the time.

No significant difference was observed in the virus detection sensitivities of the various virus-adsorbent media tested.

At inputs of 36 to 100 PFU or $TCID_{50}$/volume of water tested, coxsackieviruses A21 and B6, echoviruses 1, 13, 24, and 27 and adenovirus 15 were detected in 380- and 1,900-liter quantities of water.

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Hoehn, R.C. (1976). *Comparative Disinfection Methods.* **J AMER WATER WORKS ASSN, 68(6)**:302-8.

The problems of viruses in water are briefly discussed within a review on methods for disinfecting water.

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Hughes, D.E., Stafford, D.A. (1976). *The Microbiology of the Activated-Sludge Process.* **CRIT REV ENVIRON CONTRL, 6(3)**:233-56.

The problems of viruses in sewage are discussed briefly within an extensive analysis of the microbiology of the activated sludge process.

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Johnson, P.T. (1976). *A Herpeslike Virus from the Blue Crab,* Callinectes sapidus. **J INVERT PATHOL, 27(3)**:419-20.

Herpesvirus-like particles were detected by electron-microscopy in hematopoietic tissue of a Blue Crab *(Callinectes sapidus)* harvested from Chincoteague Bay. The particles were hexagonal and pentagonal, approximately 118 nm in diameter, and contained a nucleoid. Larger particles were seen that may have been enveloped. The nuclear material of the cells that contained the virus-like particles was Feulgen-positive suggesting that the particles contained DNA.

This is the second report of a herpesvirus-like particle in invertebrates; a herpesvirus-like particle was detected earlier in heat-stressed oysters *(Crassostrea virginica).*

$\eta\ \zeta\ \lambda$

Kalitina, T.A. (1975). *A Method for Isolating Enteroviruses in Meat.* **VOPR PITAN, (6)**:52-5. **Russian.**

Echovirus 11 was detected in stewed beef that had been seeded with 200 ID_{50} of the virus/gm, but not in beef that had been seeded with 20 ID_{50}/gm. The virus was also detected in meat cutlets that had been seeded with 3×10^5 ID_{50}/gm, but not in cutlets seeded with 30 ID_{50}/gm.

All of the poliovirus was recovered from beef seeded with more than 10^6 ID_{50} by elution of the virus with 8 to 9 volumes of saline.

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Kaiter, S.S., Millstein, C.H. *Animal-Associated Viruses in Water.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 50-60.

Viruses of many different types and heterogeneous non-human sources may find their way into water supplies. These include viruses of farm animals and wild life, fish, amphibia, plants, insects, and bacteria. Although few, if any, of these viruses produce acute diseases in man, it is not known whether any of these viruses produce latent infections or tumors in man.

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Kantoch, M., Dobrowolska, H., Jarzabek, Z., Jankowski, M. (1975). *Studies in Distribution and Characteristics of Poliovirus Strains Circulating in Poland in 1968-1972.* **MED DOSW MIKROBIOL, 27(4)**:365-72. **Polish.**

Epidemic poliovirus strains recovered in Poland in 1968, especially early in the year, were antigenically related to USOL-D-*bac.* All of the strains tested were distant antigenically from *Leon 12a,b.*

Strains from sporadic cases and from sewage contained rct and IST markers that were close to, intermediate, and distant from those typical of the attenuated strains. From sporadic cases in 1970 to 1972, strains with antigenic structure similar to that of the vaccine attenuated strains were recovered.

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Katzenelson, E. *Virologic and Engineering Problems in Monitoring Viruses in Water.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 152-64.

Our capability for recovering small numbers of viruses from large volumes of water is limited by factors peculiar to viruses and by shortcomings of viral concentration and recovery technics. The many viruses that may occur in water cannot all be detected in the same cell culture and animal systems and some cannot yet be recovered in any. Neither are all viruses recovered with equal efficiency by concentration methods. The effectiveness of concentration methods is affected by the quality of water under test.

Except with new technics such as fluorescent antibody methods currently under test, days to weeks are required for recovering and identifying viruses in various waters.

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Katzenelson, E., Biedermann, N. (1976). *Disinfection of Viruses in Sewage by Ozone.* **WATER RES, 10(7)**:629-31.

When poliovirus 1-seeded filtered sewage was added to buffered ozone, the ozone disappeared immediately. The concentration of virus was reduced immediately, but the disappearance of ozone was accompanied by a stabilization of virus titer in the effluent. The extent of virus inactivation depended upon the concentration of ozone and on the amount of interfering organic matter in the effluent.

When ozone was bubbled into poliovirus 1-seeded filtered sewage, inactivation of the virus began after about 30 seconds, even before ozone was detected in the sewage. Inactivation of 99.999% of the virus occurred in two minutes with an ozone residual of about 0.6 mg/liter. When ozone was bubbled into virus-seeded buffer, 99.999% of the poliovirus was inactivated in less than one minute with an ozone residual of about 1.0 mg/liter.

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Katzenelson, E., Bulum, I., Shuval, H.I. (1976). *Risk of Communicable Disease Infection Associated with Wastewater Irrigation in Agricultural Settlements.* **SCIENCE, 194(4268)**:944-6.

The incidence of shigellosis, salmonellosis, typhoid fever, and infectious hepatitis were two to four times higher in 77 kibbutzim (agricultural communal settlements in Israel) that practiced spray irrigation with non-disinfected oxidation pond effluent than in 130 kibbutzim that practiced no form of wastewater irrigation.

No significant differences in the incidences of streptococcal infections, tuberculosis, and laboratory-confirmed cases of influenza were apparent in the two groups. No differences in enteric disease rates during the winter non-irrigation season were evident in the two groups either.

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Katzenelson, E., Fattal, B., Hostovesky, T. (1976). *Organic Flocculation: an Efficient Second-Step Concentration Method for the Detection of Viruses in Tap Water.* **APPL ENVIRON MICROBIOL, 32(4)**:638-9.

A method is described for second-step concentration of viruses from water. This method, combined with an adsorption-elution method, yields a mean recovery of about 75%.

Poliovirus 1, seeded into 3% beef extract, was recovered with an average efficiency of 100% by precipitating the beef extract at pH 3.5 or 4.0 and dissolving the precipitate in a small quantity of 0.15 M Na_2HPO_4 at pH 9. A 20-fold concentration of the virus was achieved.

This organic flocculation procedure, applied as a secondary concentration step after adsorption of poliovirus 1 from 500 liters of seeded tap water onto 0.45μm pore size epoxy-fiberglass-asbestos filters (AA Cox M 780), and elution of the adsorbed virus with 300 ml of 3% beef extract at pH 9.0, resulted in an average virus recovery of 74.4% (range 60-91%). Parallel studies with the tentative standard method (Standard Methods for the Examination of Water and Wastewater APHA, AWWA, WPCF, Washington, D.C., 1976), in which elution of the virus from the membrane is achieved with glycine buffer at pH 11.5 and reconcentration is brought about by readsorption on a smaller membrane at pH 3.5 and a second elution in a smaller volume of elutant, yielded a recovery of only an average 35% (range 30-47%).

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Kiker, C.F. *Economic Aspects of Virus Inactivation in Waste Treatment.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 137-53.

The economics for destroying viruses in sludges is permeated with uncertainty. Policy makers have little benefit and cost information available upon which to base decisions.

Communities that take early actions and build facilities for removing and destroying viruses in sludges and wastewaters will create necessary decision-making knowledge for those communities that do so later.

$\xi \pi \delta \theta$

Krejs, G.J., Gassner, M., Blum, A.L. (1975). *Epidemiology of Infectious Hepatitis.* **GASTROENTEROL FORTBILDUNGSK PRAX, 5**:1-18. **German.**

Water- and shellfish-transmitted hepatitis A are briefly discussed within a general review of infectious hepatitis.

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Lance, J.C., Gerba, C.P., Melnick, J.L. (1976). *Virus Movement in Soil Columns Flooded with Secondary Sewage Effluent.* **APPL ENVIRON MICROBIOL, 32(4)**:520-6.

Secondary sewage effluent seeded with 3 x 10^4 PFU of poliovirus 1 (LSc)/ml was passed through columns 250 cm in length packed with calcareous sand from an area in the Salt River bed used for groundwater recharge with secondary effluent. Viruses were detected in 5 of 43 100-ml samples of the drainage water from the column. Most of the viruses were adsorbed in the top 5 cm of soil. Viruses were not detected in 1-ml samples extracted from the columns below the 160 cm level.

Infiltration rates between 15 and 55 cm/day did not affect the degree of removal of viruses. The top several centimeters of soil did not saturate with viruses and the movement of viruses was not affected when the column was saturated continuously for 27 days with the sewage-virus mixture. Deionized water desorbed viruses from the soil and increased their movement through the columns. The addition to the columns of deionized water that contained $CaCl_2$ and then sewage started a virus front moving, but the viruses were readsorbed and none was detected in outflow samples.

Desorption was reduced when soils were dried for one day between application of viruses and flooding with deionized water. Drying for 5 days prevented desorption.

Large reductions (99.99% or more) in virus numbers should occur after passage of secondary effluent through 250 cm of calcareous sand similar to that used in the columns unless heavy rains fall within one day after the application of sewage. The movement of viruses through soils in recharge basins might be minimized by the proper management of flooding and drying cycles.

$\chi \zeta$

Larkin, E.P., Tierney, J.T., Sullivan, R. *Persistence of Poliovirus 1 in Soil and on Vegetables Irrigated with Sewage Wastes: Potential Problems.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 119-30.

Poliovirus 1, flooded onto soil in seeded sewage sludge and effluent, survived for at least 96 days during the winter months.

On vegetables, spray-irrigated with seeded effluent, the virus survived for 36 days during the summer.

The application of sewage sludges and effluents onto fields on which crops that are consumed raw are grown is hazardous. Contaminated crops that enter the household in the raw state and later are cooked are also hazardous, because such foods, before they are cooked, may contaminate other foods.

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Laveran, H., Beytout, D., Charrier, F. (1976). *Adsorption of Enteroviruses on Cellulose Nitrate Membranes: Influence of Mineral Salts, Detergents, and Calf Serum.* **ANN MICROBIOL, 127(3)**:439-46. **French.**

Poliovirus 2 in distilled water, with or without added salts (NaCl, $MgCl_2$, $AlCl_3$), adsorbed to cellulose nitrate membranes. The greatest adsorption occurred when NaCl was present. Adsorption did not occur when detergent was added to the virus suspensions or when membranes were treated with calf serum before the virus was filtered through.

The adsorbed enteroviruses were eluted from the membranes with alkaline or proteinaceous buffers.

ξ γ ρ

Lemke, H.S., Sinskey, A.J. *Viruses and Ionizing Radiation in Respect to Waste-Water Treatment.* **In "Radiation for a Clean Environment." Proceedings of the Internationl Symposium on the Use of High-Level Radiation in Wastewater Treatment—Status and Prospects, Munich, March 1975. International Atomic Energy Agency, Vienna, Austria** (1975), 99-120.

The effects of ionizing radiation on viruses are reviewed. The radiosensitive target of ionizing radiation is believed to be the nucleic acid of the virus. Temperature and the nature of the suspending menstruum affect the rate of the inactivation reaction. The effect of oxygen on the reaction is unclear.

δ υ

Lennette, E.H. *Problems Posed to Man by Viruses in Municipal Wastes.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 1-7.

Whether terrestrial deposits of municipal wastes are an infectious disease threat depends upon the pathogens in the wastes and on factors in the circumambient environment.

All available epidemiological data point to person-to-person transmission as the principal mechanism of infection with viruses in excreted wastes. Although viruses may be present in solid and other wastes discharged to the environment, public health workers

should base recommendations for protecting populations from hazards in the environment on established epidemiological patterns rather than upon presumptions of possibility.

ξ γ

Lewis, N.F. *Scope for Utilizing Gamma Radiation for Microbiological Control of Sewage Waste-Water in India.* **In "Radiation for a Clean Environment." Proceedings of the International Symposium on the Use of High-Level Radiation in Wastewater Treatment—Status and Prospects, Munich, March 1975. International Atomic Energy Agency, Vienna, Austria** (1975), 197-202.

The doses of ionizing radiation that are lethal for viruses are briefly reviewed within a discussion of the usefulness of gamma radiation for the control of the microbial populations in sewage.

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Lo, S., Gilbert, J., Hetrick, F. (1976). *Stability of Human Enteroviruses in Estuarine and Marine Waters.* **APPL ENVIRON MICROBIOL, 32(2)**:245-9.

Salinity did not affect the survival of poliovirus 1, echovirus 6, or coxsackievirus B5 in autoclaved artificial sea water under controlled laboratory conditions or in autoclaved natural sea water. In the natural sea water system, the viruses and the sea water were placed in dialysis tubes and suspended in free-flowing estuarine or sea water. The viruses survived much longer in the sterile artificial sea water than in the sterile natural sea water.

In the natural sea water system, less than 99% of coxsackievirus B5 was destroyed in 80 days at 4 C to 16 C (winter), although 99.999% of the virus was destroyed in less than 50 days at 21 C to 26 C (summer). The poliovirus 1 and the echovirus 6 were destroyed more rapidly under similar conditions.

ξ ν γ

Lund, E. *Public Health Aspects of Waste-Water Treatment.* **In "Radiation for a Clean Environment." Proceedings of the International Symposium on the Use of High-Level Radiation in Wastewater Treatment—Status and Prospects, Munich, March 1975. International Atomic Energy Agency, Vienna, Austria,** (1975), 45-60.

The bacteria, viruses, and protozoan parasites in waste and polluted waters that are pathogenic to man are described. The efficiencies of conventional wastewater treatments in removing the pathogens is reviewed.

At present, conventional treatments cannot produce effluents free from pathogens that are present in untreated wastewaters. Pathogens in sludges may be destroyed by pasteurization.

ξ ρ γ

Lund, E. *Disposal of Sludges.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 196-205.

Viruses were recovered more frequently from primary sludges than from corresponding raw sewage. The concentration of viruses in these sludges ranged from 10 to 1,000 TCD_{50}/ml. Most of the viruses in slidges are bound to particulate matter.

Secondary sludges yield only 1 to 10% of the number of viruses recovered from primary sludges. Sludges from chemical flocculation of effluents also contain viruses. Even limed sludges formed at pH 10.5 have yielded viruses.

Viruses have also been recovered from sludges digested at 37 and 50 C. Land disposal of sludges may portend hazards to health. Efforts should be made with most sensitive methods available to detect viruses in sludges before those sludges are disposed to the environment.

π δ θ

Mackowiak, P.A., Caraway, C.T., Portnoy, B.L. (1976). *Oyster-Associated Hepatitis: Lessons from the Louisiana Experience.* **AMER J EPIDEMIOL, 103(2)**:181-91.

An outbreak of oyster-associated hepatitis that occurred in Louisiana during October and November, 1973 was apparently related directly to two similar outbreaks that occurred at the same time in Houston, Texas and Calhoun, Georgia. The oysters incriminated in all three outbreaks were traced to approved oyster growing areas along the east Louisiana coast. Fecal pollution of the oyster beds may have been brought about by flooding of the Mississippi River.

Epidemiologic and environmental data were consistent with recent experimental evidence which indicated that under natural conditions shellfish eliminate bacteria and viruses at different rates and may retain certain enteroviruses for as long as two months after they have disappeared from surrounding waters.

ξ δ θ

Mahdy, M.S. *Geographic Considerations in Virus Removal in the Americas.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 221-35.

Geographic factors that affect the problems that are posed by viruses in the environment may be man-related, virus and virus-host-related, or environment-related. Man-related factors include population densities, occupations, socio-economic conditions, and sanitation. Virus- and virus-host related factors include differences in virus types and strains recovered from different areas, recoverability of viruses by available technics, quantities and duration of virus shedding, ratios of inapparent to apparent infection, and

sensitivities of viruses to the environment. Environment-related factors include areas of inhabitable land, climatic and topographic conditions, availability and quality of water, and presence of vectors of virus transmission.

An analysis of data on the incidences of hepatitis A in different areas of the United States and on the qualities of water supplies, as measured by coliform determinations, suggested a correlation between the incidence of the disease and the quality of the available water.

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Malina, J.F., Jr. *Viral Pathogens Inactivation During Treatment of Municipal Wastewater.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 9-23.

The inactivation and removal of viruses from sewage and sludges by treatment procedures are reviewed.

The lack of parallelism in the inactivation and removal of polioviruses and bacteriophages by these processes is noted.

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Maynard, J.E. (1976). *Hepatitis A.* **YALE J BIOL MED, 49(3)**:227-33.

The transmission of hepatitis A by water is briefly noted within a broad review of the disease.

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Melnick, J.L. *Viruses in Water. An Introduction.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 3-11.

The author recounts his experiences as an early water virologist from his persistant recoveries of polioviruses from New York City sewage during poliomyelitis outbreaks in the mid 1940's, through the massive hepatitis A epidemics in New Delhi in 1955, to the present.

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Melnick, J.L., Gerba, C.P., Wallis, C., Hobbs, M.F. *Photodynamic Inactivation of Virus in Sewage.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 25-36.

Because of the requirements for elevated pH and for light, which is energy-intensive, photodynamic oxidation is usually a more expensive disinfection process than chlorination. But, in water treatment plants where the pH-elevating lime-softening process

is used, the cost of photodynamic oxidation is greatly reduced. Moreover, sunlight is an effective alternative energy source to expensive artificial light.

Disinfection by photodynamic oxidation may be an especially useful alternative to chlorination in situations where the formation of chlorinated carcinogenic compounds must be avoided.

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Merson, M.H., Morris, G.K., Sack, D.A., Wells, J.G., Feeley, J.C. Sack, R.B., Creech, W.B., Kapikian, A.Z., Gangarosa, E.J. (1976). *Travelers' Diarrhea in Mexico.* **NEW ENGLAND J OF MED, 294(24)**:1299-1305.

Forty-nine percent of 73 physicians and 48 family members who attended a medical congress in Mexico City and participated in a prospective study of travellers' diarrhea became ill with diarrhea. The median duration of illness was five days. The median day of onset was six days after arrival.

An etiologic agent was recovered from 63% of the patients. Enterotoxigenic *Escherichia coli* of different, *non-enteropathogenic* serotypes appeared to be the most common causes of the diarrheas; other apparent etiologic agents included salmonellae, invasive *E. coli*, shigellae, *Vibrio parahaemolyticus, Giardia lamblia* and a reovirus-like agent. Consumption of salads that contained raw vegetables was associated with enterotoxigenic *E. coli* infections.

Travelers' diarrhea in Mexico appears to be a syndrome caused by a variety of pathogens, the most common of which are enterotoxigenic *E. coli.*

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Metcalf, T.G. *Prospects for Virus Infections in Man and Animals from Domestic Waste Land Disposal Practices.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 97-117.

Spray irrigation with sewage effluents is the waste disposal procedure most likely to cause infections in man and animals. Injection of wastes into soils appears to offer the least opportunity for dissemination of viruses among man and animals.

The likelihood of disease outbreaks in man in the vicinities of land disposal sites (when disposal is other than by spray irrigation) seems remote.

γ

Morin, R.A., Keller, J.W., Schaffernoth, T.J. *Ozone Pilot Plant Studies at Laconia, New Hampshire.* **In "Proceedings of Symposium—New Trends in Water and Sewage Treatment Using Pure**

Oxygen and Ozone," Denver, Colorado, October 1974. U.S. Bureau Reclamation, Engineering Research Center, Denver, Colorado (1975), 99-119.

This paper is essentially the same as **Morin, R.A., Keller, J.W., Schaffernoth, T.J., Paquette, D.R.** (1975). *Ozone Disinfection Pilot Plant Studies at Laconia, New Hampshire,* **J NEW ENG WATER WORKS ASSN, 89(3)**:206-4. *See 1975 Literature Abstracts.*

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Mosley, J.W. (1975). *The Epidemiology of Viral Hepatitis: An Overview.* **AM J MED SCI, 270(2)**:253-70.

Water- and shellfish-transmitted hepatitis A are briefly discussed within a comprehensive review of infectious hepatitis.

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Nestor, I., Costin, L. (1976). *Presence of Certain Enteroviruses (Coxsackie) in Sewage Effluents and in River Waters of Roumania.* **J HYG EPIDEMIOL MICROBIOL IMMUNOL, 20(2)**:137-49.

In studies from 1962 to 1976 in Roumania, coxsackieviruses A and B were recovered with the gauze pad procedure from 29% of the sewage samples and from 15% of the river water samples tested. Sixty-five samples of aqueduct water yielded two viruses, and 39 samples of sand filter effluents yielded three viruses. In river water, the frequency of virus recoveries decreased as distance from the pollution sources increased.

Viruses were recovered by the gauze pad tecnnic. The viruses were concentrated from gauze pads by the Amberlite method, the yeast cell method, or the aluminum hydroxide method.

With river and aqueduct waters and sand filter effluents, the yeast cell concentration method yielded the most viruses.

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Niemi, M. (1976). *Survival of* Escherichia coli *Phage T7 in Different Water Types.* **WATER RES, 10(9)**:751-5.

Coliphage T7 survived longer in the dark in ground water than in river water, pulp wastewater, lake water, or brackish water.

At 20 C, 99.9% of the virus was inactivated in 8 to 18 days in river water, in 20 days in pulp wastewater, in 10 to 16 days in lake water, and in 10 to 14 days in brackish water.

At 3 C, 90% of the virus was inactivated in 10 to 22 days in river water, in 20 to 25 days in paper pulp wastewater, in 15 to 30 days in lake water, and in 8 to 30 days in brackish water.

At 3 C and 20 C, less than 5% of the virus was inactivated in ground water after 32 days of storage.

Differences in the rate of inactivation of the virus occurred, without apparent pattern, in waters sampled in winter and summer.

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Nikolaeva, T.A., Bagdasaryan, G.A., Itskova, A.I., Talaeva, Y.G. (1975). *Hygienic Aspects of Microbial Contamination of Water Basins.* **VESTN AKAD MED NAUK, 3**:46-52. **Russian.**

The survival of viruses in waters is discussed briefly within a review of recreational and other water problems.

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Novikov, Y.V. (1975). *Hygienic Problems of the Ozonization of Drinking Water.* **KAZAN MED ZH, 56(5)**:77-9. **Russian.**

The inactivation of enteroviruses by ozone is discussed briefly in a review of the treatment of drinking water with ozone.

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Nupen, E.M. *Viruses in Renovated Waters.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 189-95.

The degree to which tertiary sewage treatment intended to renovate waters removes viruses is evaluated, and the work yet to be done in order to meet rigid standards for viruses in renovated waters is assessed.

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Olivares, A.L. (1974). *Distribution of Enteroviruses in Spain. Laboratory Methods for Their Study.* **REV SANID HIG PUBLICA, 48(11)**:1021-65. **Spanish.**

This paper was listed in the 1975 edition of these abstracts. A translation was not then available.

From January 1972 to August 1973, during a period of epidemic poliomyelitis, seven strains of polioviruses 1, 2, and 3, one strain of echovirus 7, one strain of a coxsackievirus B and two unidentified enteroviruses were recovered from a total of 30 samples of sewage taken in Madrid province.

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Oliver, B.G., Carey, J.H. (1976). *Ultraviolet Disinfection: An Alternative to Chlorination.* **J WATER POLLUT CONTRL FED, 48(11)**:2619-24.

The resistance of *Escherichia coli* to ultraviolet light, ozone, and chlorine is compared with that of several pathogenic enteric bacteria and viruses within the framework of a review of disinfection with ultraviolet light.

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Olumide, E.A. (1976). *The Distribution of Hepatitis B Surface Antigen in Africa and the Tropics: Report of a Population Study in Nigeria.* **INT J EPIDEMIOL, 5(3)**:279-89.

The incidence of HB_SAg by complement fixation tests was 12.6% in an urban high socioeconomic area and in the central slum area of an African city.

In the slum area, a significant association occurred between the presence of the antigen and the type of latrine in the house, the number of blood tests done within two years of the study, and receipt of injections in a dispensary. In the high socioeconomic area, a lack of protection from mosquitoes was significantly associated with the presence of antigen.

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Payment, P., Gerba, C.P., Wallis, C., Melnick, J.L. (1976). *Methods for Concentrating Viruses from Large Volumes of Estuarine Water on Pleated Membranes.* **WATER RES, 10(10)**:893-6.

Poliovirus 1, seeded into 380 liters (100 gallons) of acidified seawater (pH 3.5), was concentrated into a final eluate volume of 20 to 100 ml. Fifty percent of the virus was recovered; a concentration of 20,000 to 100,000 was achieved.

The viruses were recovered in a Wallis-Melnick concentrator equipped with 3- and a 0.45-μm pore size pleated cellulose nitrate membrane filters. The flow rate through the filters was about 22 liters (6 gallons)/minute. Viruses were eluted from the pleated filters with glycine buffer (pH 22.5) and reconcentrated by precipitation with $FeCl_3$ or $AlCl_3$.

The filters still adsorbed viruses after 2,268 liters (600 gallons) of turbid estuarine water had been passed through them.

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Peleg, M. (1976). *The Chemistry of Ozone in the Treatment of Water.* **WATER RES, 10(5)**:361-5.

The dissociation products of ozone in water may be more powerful oxidizing agents than ozone itself.

The hydroxyl radical (OH) may be responsible for the high oxidative and germicidal potentials that occur when ozone is added to water, but the OH radical preferentially reacts with organic substances when these are present.

The disinfection capability of other products of ozone dissociation in water (HO_2, O_3^-, O_2^-, and O^-) are not yet known.

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Pietri, C., Breittmayer, J.-P. (1976). *Study of the Survival of an Enterovirus in Ocean Water.* **REV INT OCEANOGR MED, 41-42**:77-84. **French.**

In laboratory studies at 18 C, poliovirus 1 survived longer in autoclaved sea water than in filtered sea water, and longer in fil-

tered sea water than in natural sea water. The sea water samples were exposed continuously to alternate 12-hour periods of darkness and artificial light.

In 60 days, about 5% of the virus was destroyed in autoclaved sea water, and about 99.5% of the virus was destroyed in filtered sea water. About 99.95% of the virus was destroyed in natural sea water after about 40 days.

ξ ν μ φ

Prozesky, O.W. (1975). *Viruses in Water.* **GENEESKUNDE, 17(8)**:162-5. **Afrikaans.**

The presence of viruses in the water environment, the detection of these viruses, the effect of water purification processes on them, and the viral standards for water purity are reviewed and discussed.

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Quarles, J.R., Jr. *Viruses in Water. Legal and Regulatory Decisions and Dilemmas.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 209-17.

Recent federal laws impacting USEPA research programs are recounted and the USEPA research programs in water are described against the background of a discussion of water needs and water pollution problems in the United States.

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Rao, N.U. *Geographic Considerations in Virus Removal in Asia.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 236-46.

The concentration of enteric viruses in the aquatic environment in Asia is much greater than in developed countries. The proportion of children under age 15, where the highest incidence of excretors occurs, is much higher in Asia than in developed nations. Sewage treatment receives a low priority in the competition for scarce funds in underdeveloped countries.

People deserve adequate and safe water whether they live in underdeveloped or developed countries, whether they are poor or well-to-do. In poor countries, however, progress in this direction, although noticeable, is slow.

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Rao, V.C. (1976). *Monitoring, Prevention and Control of Viral Pollution of Water.* **J INST PUBLIC HLTH ENGRS (IPHE), India, (3)**:51-9.

In India, untreated domestic wastes that contain large numbers of human enteric viruses are commonly discharged into wa-

ter courses, most of which are used as potable water sources by downstream communities.

Methods for monitoring waters for viruses and for prevention and control of the pollution of waters with viruses are described within a review of the waterborne viral problem in India and in other parts of the world.

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Rao, V.C. (1976). *Virus Transmission Through Foods.* **J FOOD SCI TECHN, 13(6)**:287-93.

Methods for recovering viruses from shellfish are discussed within a review of the problem of the transmission of viruses by foods.

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Reali, D., Caroli, G., Levre, E. (1975). *Salmonellae,* E coli *and Their Homologous Phages in Seawater.* **INN SCLAVO, 17(6)**:842-7. **Italian.**

Although coliform bacteria are the most important index of the degree of fecal contamination of water, other important indices also exist. The quantitative determination of salmonellae, now possible with modern procedures, can indicate the extent of contamination with those pathogens and can provide, therefore, a better determination of the extent of danger of a water.

Coliphages and phages of *Salmonella typhosa* and *S. typhimurium* may also be useful indicators of the degree of contamination of a water. Phages may still be present in water after the bacteria in which they originated have disappeared.

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Reeves, W.C., Peters, C.J. (1976). *The Seroepidemiology of Reovirus, Coxsackievirus B, and Hepatitis B Virus Infections Among Panamanian Indian Children,* **J INFECT DIS, 133(3)**:268-73.

The rates of infection with hepatitis B virus varied significantly among Panamanian indian tribes. The prevalance of antibody to HB_sAg was greater in Choco and mainland Cuna Indians than in Guaymi and island Cuna indians.

In children ten years old or younger, serological studies indicated that infection with group B coxsackieviruses occurred more frequently in Ghoco and mainland Cuna indians than in Guaymi or island Cuna indians. Although almost all children tested had been exposed to reoviruses, mainland Cuna indian children had the highest geometric mean titers of antibody, followed by Choco, Guaymi, and island Cuna indians, in descending order.

This parallel in rates of hepatitis B and enteric virus infections supports the hypothesis that fecal-oral transmission of hepatitis B virus is important in certain populations.

The village water supplies appeared to be the major environmental difference that distinguished one tribe from another.

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Reynolds, B.J. *An Example of Sewage Disposal by Spray Irrigation.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976). 218-20.

Effluents from a series of stabilization lagoons fed with animal manure were applied to crops and woodlands which removed nutrients and produced effluents from which viruses could not be recovered and which met the tertiary treatment requirements of the Pennsylvania Department of Environmental Resources.

ξ γ

Richards, W.N., Shaw, B. (1976). *Developments in the Microbiology and Disinfection of Water Supplies.* **J INST WATER ENGRS SCI, 30(4)**:191-202.

The problems of viruses and pathogenic bacteria in water supplies are noted briefly in a review of disinfection methods.

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Safferman, R.S., Morris, M.-E. (1976). *Assessment of Virus Removal by a Multi-Stage Activated Sludge Process.* **WATER RES, 10(5)**:413-20.

In a 50,000 gpd three-stage activated sludge pilot plant seeded with coliphage f2, 95% of the virus was removed in each the denitrification and the high-rate activated sludge modules. The combined unit processes removed more than 99.97% of the virus from sewage.

The large variations that occurred in the numbers of viruses in sewage over a 24-hour period demonstrated the importance of obtaining temporally-related samples within the treatment system.

A correlation between the numbers of coliphages and the numbers of enteroviruses in the primary effluent could not be demonstrated.

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Salo, R.J., Cliver, D.O. (1976). *Effect of Acid pH, Salts, and Temperature on the Infectivity and Physical Integrity of Enteroviruses.* **ARCH VIROL, 52**:269-82.

At 2 C and 30 C, enteroviruses were more stable at acid pH levels than at alkaline pH levels. NaCl and other chlorides increased the rate of inactivation of poliovirus at pH 3. The effect of NaCl was considerably less at pH levels of 4.5 to 7.0 than at pH levels below 4.5. The RNA of the virion became non-infective as rapidly as the intact virion did, except at pH 3 in the presence of $MgCl_2$.

Inactivation resulted in alterations to the physical integrity of enteroviruses. At pH 5 and 7, the RNA of the poliovirus became hydrolyzed; at pH 3, 5, 6, and 7, the nucleic acid of the virion be-

came susceptible to ribonuclease. Only at pH 3 were virions sensitive to chymotrypsin.

The hemagglutinins of echovirus 7 were destroyed when virions were inactivated at pH 3, 4, 5, and 6; but, at pH 6 this alteration preceded the loss of infectivity.

The pH of the suspension was a primary determinant of the mechanism of virus destruction and possibly of the loss of infectivity at 2 C and 30 C.

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Sattar, S.A., Ramia, S., Westwood, J.C.N. (1976). *Calcium Hydroxide (Lime) and the Elimination of Human Pathogenic Viruses from Sewage: Studies with Experimentally-Contaminated (Poliovirus type 1, Sabin) and Pilot Plant Samples.* **CAN J PUBLIC HLTH, 67(5-6)**:221-6.

When added in a quantity sufficient to raise the pH of sewage to 11.5, lime removed or destroyed most of the 30 to 40 million PFU of poliovirus 1 seeded into it.

In eight experiments with different samples of sewage, none of the seeded poliovirus 1 was detected in the supernates. The poliovirus recovered from the sludges represented only 0.01% of the input virus. The virus was not recovered from sludges after the sludges had been stored for 24 hours at 28 C.

The lime process removed viruses equally well at 4 C.

$\lambda\,\rho$

Sattar, S.A., Westwood, J.C.N. (1975). *A Method for the Isolation of Indigenous Human Viruses from Sludge.* **IRCS MED SCI, 3**:431.

More viruses were eluted from centrifuged sludge solids with 10% fetal calf serum than with 3% beef extract. Elution of viruses from sludge solids with 3% lactalbumin hydrolysate yielded relatively few viruses.

$\lambda\,\rho$

Sattar, S.A., Westwood, J.C.N. (1976). *Comparison of Four Eluents in the Recovery of Indigenous Viruses from Raw Sludge.* **CAN J MICROBIOL, 22(10)**:1586-89.

In tests with 20 different samples of raw sludge, 3% beef extract eluted viruses from 15 (75%), and 10% fetal calf serum eluted viruses from 19 (95%) of the samples. Casein hydrolysate and lactalbumin hydrolysate were ineffective elutants.

The viruses were recovered in BSC-1 cells.

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Sattar, S.A., Westwood, J.C.N. (1976). *Comparison of Talc-Celite and Polyelectrolyte 60 in Virus Recovery from Sewage: Development of Technique and Experiments with Poliovirus (Type 1, Sabin)-Contaminated Multilitre Samples.* **CAN J MICROBIOL, 22(11)**:1620-7.

Poliovirus 1 seeded into 100 ml of sewage was recovered by adjusting the pH of the sewage to 6 and filtering it through either a layer of PE 60 (400 mg) or through a layer of talc (300 mg)-Celite (100 mg). The adsorbed virus was eluted from the adsorbants with 100 ml of 10% fetal calf serum in saline, pH 7.2. The seed concentration of viruses was 45 to 60 PFU. From 73 to 80% of the virus was recovered on the PE 60 layers and from 65 to 70% of the virus was recovered on the talc-Celite layers.

From 33 to 63% of the poliovirus was recovered from talc (15 gm)-Celite (5 gm) layers through which five liter-quantities of sewage seeded with 50 to 1.26 x 10^5 PFU of the virus had been passed. The virus was eluted with 50 ml of the 10% fetal calf serum in saline.

Except for pH adjustment and prefiltration through two layers of gauze to remove large solids, no sample pretreatment was necessary.

With these filtration technics, indigenous viruses have been recovered from field samples of raw sewage and effluents.

Schaub, S.A., Sorber, C.A. *Viruses on Solids in Water.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 128-38.

EMC viruses (rodent enteroviruses), polioviruses, and coliphages, adsorbed to solids, retain almost complete infectivity for cell cultures. Enteroviruses adsorbed to clay are as infective *in vivo* as enteroviruses in suspending medium without clay.

Viruses adsorb to colloids and solids in water to a degree dictated by physical-chemical conditions. Adsorption and elution of viruses to and from solids are affected by the nature of the adsorbing material, the concentration and valence of metal cations present, the nature of the virus (isoelectric point, whether unenveloped or enveloped), pH, the presence of organic and inorganic interfering substances, and time.

Viruses adsorbed to solids assume the dispersal characteristics of the solids and probably are carried in the water until the water velocity is low enough to allow the solids to settle. Increased water velocity may resuspend the solids and the adsorbed viruses. Rain reduces the concentration of cations in water and may thereby release viruses from solids. Organic materials from domestic and industrial waste effluents and from land runoff may elute viruses by competitive replacement at adsorption sites.

Generally, all waters reach the oceans. But, the oceans should not be regarded a final sink for viruses, because infection of man may occur from ingestion of virus-contaminated shellfish.

Many methods used to concentrate viruses in natural waters and wastewaters do not recover viruses adsorbed to suspended matter.

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Schmidt, N.J., Ho, H.H., Lennette, E.H. (1975). *Propagation and Isolation of Group A Coxsackieviruses in RD Cells.* **J CLIN MICROBIOL, 2(3)**:183-5.

A number of group A coxsackieviruses, including A5 and A6, multiplied in a cell line designated RD that had been derived from a human rhabdomyosarcoma. Coxsackieviruses A5 and A6, heretofore, had been propagated only in suckling mice.

Several group A coxsackieviruses that replicate in other cell lines multiplied to higher titers in RD cells.

In limited tests, RD cells were slightly less sensitive than suckling mice for recovering group A coxsackieviruses from clinical specimens.

Group B coxsackieviruses replicated poorly or not at all in RD cells.

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Schwartzbrod, J., Dixneuf, P., Schwartzbrod, L., Brochet, J.-C. Folliquet, J.-M. (1975). *Study of the Behavior of Poliomyelitis Virus Type 1 in Different Hydrous Media.* **REV EPIDEM MED, 23(4-5)**:235-52. **French.**

At 18 C to 24 C, poliovirus 1 survived about 296 days at pH 6.9 in buffer and in buffer that contained soil extract.

Extrapolations from data that extended only to 550 days suggested the virus would survive for 10 to 15 years at 4 C.

The poliovirus concentration in the buffers was more than 10^5 MPNCU/ml.

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Sharp, D.G., Floyd, R., Johnson, J.D. (1976). *Initial Fast Reaction of Bromine on Reovirus in Turbulent Flowing Water.* **APPL ENVIRON MICROBIOL, 31(2)**:173-81.

The destruction of single particles of reovirus by bromine followed first-order kinetics. At 2 C, 3-μM of bromine/liter reduced the plaque titer of the virus at the rate of 3 $\log_{10}$ units/second at pH 7. The rate of destruction by bromine of virions in aggregates of 2 to 10 per clump decreased with time. At a survival level of 10^{-3} for single virions, the aggregated preparations lost only 99% of their plaque titer. In these aggregated preparations, a survival level of 10^{-4} was reached only after four seconds of exposure to the bromine.

The destruction rate did not appear to be a simple function of the size and frequency of viral aggregates even when the aggregates did not contain foreign material.

In unpurified virus preparations (crude freeze-thaw lysates of infected cells), from 50% to more than 90% of the infectivity was contained in large, fast-sedimenting aggregates. In polluted waters, such aggregates probably influenced the rate of destruction of viruses by disinfectants.

The kinetic disinfection studies were accomplished in a newly designed device that allowed sampling at one second intervals.

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Shortridge, K.F., Hu, L.Y. (1975). *Absence of Detectable Hepatitis B Antigen (HBAg) in the Commercial Oyster,* Crassostrea gigas *Thunberg, in Hong Kong.* **SOUTHEAST ASIAN J TROP MED PUBLIC HLTH, 6(3)**:305-7.

Efforts to detect hepatitis B antigen by counter-immunoelectrophoresis in commercial oysters *(Crassostrea gigas* Thunberg) (or in extracts of oyster tissues including the digestive diverticula and mantle fluids) grown in polluted Hong Kong waters were unsuccessful. Tests for the antigen were done monthly over a one-year period and once hourly during one day in mid-summer.

Pollution of the oyster beds may have been predominantly of animal rather than of human origin. A lack of sufficient human pollution could have accounted for the apparent absence of hepatitis B antigen in the shellfish.

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Shuval, H.I. *Water Needs and Usage. The Increasing Burden of Enteroviruses on Water Quality.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 12-25.

The history of the problem of viruses in water is recounted along with the history of research into the problem and its alleviation.

The author advocates current standards of 0 viruses/100 gallons of drinking water, 0 viruses/10 gallons of recreational water, and 0 viruses/100 gallons of renovated waters.

The author suggests that these standards should be applied initially only in cities with populations in excess of 100,000 that draw their waters from polluted surface sources.

ξ π λ ι

Sigel, M.M., Rippe, D.F., Beasley, A.R., Dorsey, M., Jr. *Systems for Detecting Viruses and Viral Activity.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 139-51.

The methods used for detecting viruses are reviewed.

Sentinal systems for detecting viruses in seawater are described. In experimental systems, viruses were retained in the gills of spiny lobsters, in the gills, intestines, and livers of aplysia, and in the liver and intestines of the conch.

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Sigel, M.M., Rippe, D.F., King, S.D., Rose, E., Breakenridge, F., Dorsey, M., Jr., Watkins, S.L., Jr., Dunkley, L., Beasley, A.R. *Survival of Enteric Viruses Under Different Environmental Conditions.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 53-8.

Polioviruses in the stools of infants and young children who had been vaccinated orally with live trivalent vaccine ranged in concentration from 10^2 to $10^{4.2}$ ID_{50}/gm 10 days after vaccination. The viruses were stable in extracts prepared in Hanks' balanced salt solution for at least 19 days at -20 C, but 90% of the viruses were inactivated in 12 days at 4 C and 24 C, and 99% were inactivated in five days at 37 C. At 24 and 37 C, the viruses were even less stable in solid stools.

Coxsackievirus B4 was stable in fecal extracts for at least 10 days at 4 and 24 C, but about 95% of the virus was inactivated in five days at 37 C.

Echovirus 11 was stable in fecal extracts for at least 28 days, but the virus was increasingly less stable with rising temperatures.

Contact with paper diapers and urine increased the rate of inactivation of the polioviruses, but moisture and free air exchange did not significantly impact survival of these viruses.

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Sinskey, A.J., Shah, D., Wright, K.A., Merrill, E.W., Sommer, S., Trump, J.G. *Biological Effects of High-Energy Electron Irradiation of Municipal Sludge.* **In "Radiation for a Clean Environment." Proceedings of the International Symposium on the Use of High-Level Radiation in Wastewater Treatment—Status and Prospects, Munich, March 1975. International Atomic Energy Agency, Vienna, Austria** (1975), 139-49.

At atmospheric pressure, 99% of *Salmonella typhimurium* (R6008), bacteriophage P22, *S. typhimurium* LT 2, and *Escherichia coli* K12, in 0.0067 M phosphate buffer, were inactivated by approximately 180,000, 75,000, 40,000, and 30,000 rads of electron irradiation, respectively.

Bacteria were destroyed by electron irradiation more rapidly in blended sludge than in whole raw sludge suggesting that large clumps protected bacteria from irradiation. Irradiation of bacteria at 10 C and 35 C produced about the same rates of inactivation in sludge, but the inactivation of electron-irradiated bacteria in sludge occurred more rapidly in an atmosphere of oxygen than it did in an atmosphere of air and more rapidly in air than in nitrogen.

Irradiations were performed with a compressed gas-insulated 4 MeV Van de Graaff electron accelerator.

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Šivák, Š., Červenka, J., Tarabčak, M., Roda, J., Mayerová, A., Stilicha, O., Milošovičová, A., Sventeková, S. (1976). *The Results of Examination of Waste Waters Within the Framework of Surveillance of Poliomyelitis in Slovakia in the Years 1968-1972.* **CS EPIDEMIOL, 25(4)**:196-204. **Ukrainian.**

From 1968 to 1972 in Slovakia, 1,979 enteroviruses were recovered on gauze pads from 4,393 samples of wastewater. Of these enteroviruses, 647 (32.7%) were polioviruses.

Polioviruses were recovered from 73 of 422 (17.3%) samples of wastewater five months after vaccination programs were completed, but only sporadically in subsequent months.

The genetic markers of polioviruses recovered more than six months after the beginning of vaccination programs should be determined.

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Sivinski, H.D. *Treatment of Sewage Sludge with Combinations of Heat and Ionizing Radiation (Thermoradiation).* **In "Radiation for a Clean Environment." Proceedings of the International Symposium on the Use of High-Level Radiation in Wastewater Treatment—Status and Prospects, Munich, March 1975. International Atomic Energy Agency, Vienna, Austria** (1975), 151-67.

Ninety-nine percent of poliovirus 1 in minimal essential medium was inactivated in about 85 minutes without irradiation at 46 C, in about 200 minutes by 200 krad of gamma irradiation at 23 C, and in about 40 minutes by 200 krad of gamma irradiation at 46 C. The anticipated additive effect for the irradiation and the high temperature would have resulted in inactivation of 99% of the virus in 60 minutes. Synergism was thus suggested.

Similar synergistic inactivation in sludge occurred with *Bacillus subtilis* var. *niger* spores, coliphage T4, *Escherichia coli*, and a fecal streptococcus.

^{137}Cesium was the gamma source.

ξα

Slote, L. (1976). *Viral Aerosols—A Potential Occupationally Related Health Threat in Aerated Wastewater Treatment Systems.* **J ENVIRON HLTH, 38(5)**:310-14.

The possible transmission of viruses by aerosols from sewage treatment plants is discussed.

ιγ

Smedberg, C.T., Cannon, R.E. (1976). *Cyanophage Analysis as a Biological Pollution Indicator—Bacterial and Viral.* **J WATER POLLUT CONTRL FED, 48(10)**:2416-26.

At 25 C, 99.9% of cyanophages (*Lyngbya*, *Phormidium*, and *Plectonema*-1) in distilled water were inactivated in 20 minutes by 1 mg of chlorine/liter at pH 7.0. Under similar conditions, 99.7% of

Escherichia coli was inactivated by 0.3 mg of chlorine/liter in 20 minutes.

Field studies have shown that whenever *Lyngbya, Phormidium,* and *Plectonema* cyanophages were eliminated, the coliforms were too.

The cyanophages are practical and inexpensive viral indicators and may serve as replacements for the coliform test.

η

Sobsey, M.D. *Field Monitoring Techniques and Data Analysis.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 87-96.

The design of a field monitoring program for enteric viruses in wastes disposed to the land should consider a variety of site-specific factors such as type of wastes, nature and extent of treatment of the wastes, method for applying the wastes to the land, seasonal, climatic, and meteorological conditions, geology, hydrology, and soil characteristics, vegetative cover, intended subsequent use of the land, and the topology and population of the area.

ξ λ

Sobsey, M.D. *Methods for Detecting Enteric Viruses in Water and Wastewater.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 89-127.

With the exception of some raw sewages, enteric viruses in waters must be concentrated before they can be detected and quantified by infectivity assay procedures.

Polymer two-phase separation, polyvalent cation salt precipitation and some of the simple filter adsorption-elution systems are methods particularly well suited for small quantities of viruses.

Flow-through filter adsorption-elution systems such as the Wallis and Melnick portable virus concentrator and ultrafiltration through anisotropic, polymeric membranes in tangential flow systems show promise for concentrating small quantities of viruses from large volumes of highly treated or finished waters that are low in turbidity and dissolved organic matter.

Good methods for detecting small quantities of viruses in large volumes of turbid natural waters such as river, lake, and coastal waters are not yet available.

The use of a number of different cell culture systems permits the detection of most enteric viruses in water and wastewater. Adequate methods for recovering hepatitis A and B viruses in water and wastewater are still not available.

χα

Sorber, C.A. *Viruses in Aerosolized Wastewater.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 83-6.

The initial loss of viruses aerosolized during spray irrigation with wastewater may be as much as 30 to 40%. A die-off of 90% of the remaining viruses may be expected every 40 seconds thereafter.

Under the least desirable meteorological conditions, 99.9% of the viruses that are aerosolized should be destroyed within 200 meters of the spray nozzle.

Assuming adequate disinfection of the effluents that are sprayed, large buffer zones may be needed for esthetic purposes only in the vicinities of fields that are irrigated with sprayed effluents.

ξνγρ

Sproul, O.J. *Removal of Viruses by Treatment Processed.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 167-79.

Primary sedimentation sludges contain many viruses and must be disposed of carefully to prevent contamination of people and food crops.

In laboratory studies, coagulation of viruses in water with metal coagulants has removed 90 to 99% of the viruses. Cationic polyelectrolytes added with a metal coagulant do not affect the numbers of viruses coagulated, but when used alone effectively remove viruses. Lime can be an especially effective coagulant because the high pH it produces can be sufficient to destroy viruses.

Viruses are removed from water by sand filtration; the viruses adsorb to the sand or to particulates trapped in the sand. Filtration of the flocced waters may remove more than 90% of the previously unadsorbed virus.

Trickling filters remove relatively small amounts of viruses from sewage. Activated sludge removes more than 90% when the process is operating properly.

HOCl is an effective virucide. Chloramines are relatively slow virucides. Ozone is an effective virucide, but it has a half life of only 25 minutes.

Anticipated removals of viruses by treatment processes, assumed from laboratory data, suggest that drinking water supplies developed from contaminated waters may contain viruses.

ϕ

Sproul, O.J. *Standards for Viruses in Effluents, Sludges, and Ground and Surface Waters.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 131-5.

Data are not available that causally relate viruses in water to diseases in man, nor are systems available that are sufficiently sensitive to detect viruses in the concentrations that might be expected in a good quality effluent from a water renovation plant.

Nonetheless, goals may be established for numbers of viruses permitted in various waters. To this end 100 PFU/liter may be acceptable in sewage effluents discharged to adequately diluting surface waters or to land where the groundwater is treated before it is consumed. Four-40 PFU/10 gallons may be acceptable for surface waters.

Sufficient data are not available for establishing goals for sludges. However, treatment systems are available that can achieve any degree of inactivation of viruses desired in sludges and in wastewaters also.

ν

Sriramulu, N., Chaudhuri, M. (1976). *Dual-Media Coal-Sand Filter and Its Virus Removal Potential.* **INDIAN J ENVIRON HLTH, 18(2)**:77-86.

Filtration of effluent seeded with coliphage MS2 through dual media (Giridih bituminous coal and sand) at 9.8 meters/hour (4 gpm/ft^2) removed 92% of the virus and 85% of the turbidity from the effluent.

$\zeta\, y$

Symons, G.E., Henderson, K.W. (1976). *Disinfection—Where are We Going?* **J NEW ENG WATER WORKS ASSN, 90(3)**:199-208.

The problems of viruses in water are discussed briefly in a review of disinfection of water supplies.

ν

Veitser, Y.I., Ryabchenko, V.A., Arbuzova, N.A. (1976). *Utilization of Cationic Polyelectrolytes for Removal of Viruses from Water.* **GIG SANIT, 0(3)**:10-13. **Russian.**

Two cationic polyelectrolytes, polyvinyl-N-benzyl-tri-methyl-ammonium chloride (VA-2) and polyethyleneimine (PEI-K), effectively coagulated and removed viruses from tap and river water. Polydimethylaminomethyl-N-acryloamide (KF-4), also a cationic polyelectrolyte, was less effective.

In a concentration of 0.5 mg/liter, VA-2 removed more than 99.9% of poliovirus 1 from tap water, and in a concentration of 1 mg/liter, the polyelectrolyte removed more than 99.999% of coliphage T1 from tap water. Three mg/liter of VA-2 removed less

than 99.9% of coliphages T1 and T2 from river water, but 6 mg/liter of VA-2 removed more than 99.999% of coliphage T1 from the same water.

In a concentration of 0.5 mg/liter, PEI-K removed more than 99.9% of poliovirus 1 and more than 99.999% of coliphage T1 from tap water. Three mg/liter of PEI-K removed more than 99.99% of coliphage T1 and more than 99.5% of coliphage T2 from river water.

One mg/liter of KF-4 removed only a little more than 90% of coliphage T1 from tap water.

In tap water made turbid by the addition of 50 mg/liter of illite, 4 mg/liter of VA-2 or PEI-K removed more than 99.999% of coliphage T1.

$\xi\gamma$

Verstraete, W., Voets, J.P. (1975). *Micro-Organisms as Indicators of Environmental Hygiene: Ecology, Taxonomy and Enumeration.* **NATUURWET TYDSCHR (GHENT), 57(2)**:69-84. **Dutch.**

The paper was listed in the 1975 edition of these abstracts. A translation was not then available.

In a short review, several methods for concentrating viruses from water are briefly described.

β

von Suzani, C., Hazeghi, P. (1976). *Infections Transmitted by Frequenting Swimming Pools.* **SOZ PRAEVENTIVMED, 21(4)**:120-1. **French.**

Public swimming pools can be the source of infections with microorganisms such as *Mycobacterium balnei,* adenoviruses, enteroviruses, the agents of plantar warts, the virus of *Molluscum contagiosum,* the chlamydiae of swimming pool-conjunctivitis, and pathogenic fungi.

Pool water of satisfactory quality by standard tests, may contain pathogenic staphylococci and *Pseudomonas aeruginosa.*

Effective measures for preventing swimming pool transmission of diseases include continuous recording of the redox-potential of the water, limiting the number of visitors to the pool to pool design specifications, better disinfection of sanitary installations, regular maintenance of equipment, frequent backwashing of filters, and exclusion from the pool area of visitors with communicable diseases.

γ

Wallis, C., Gerba, C.P., Melnick, J.L. *Photodynamic Inactivation of Viruses and Bacteria in Sewage Effluents.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 180-8.

Sewage effluents may be sterilized by a photoreactive heterotricyclic dye and monochromatic light. Coliforms and poliovirus 1

may be sensitized by methylene blue and then destroyed by exposure to a source of visible light that emits energy at the wavelength of light which the dye absorbs. The logistics of photodynamic inactivation appear to be practical for wastewater disinfection.

ξλ

Wallis, C., Stagg, C.H., Farrah, S.R., Melnick, J.L. *Problems Related to the Concentration of Viruses from Large Volumes of Wastewater.* **In "Virus Aspects of Applying Municipal Wastes to Land." Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 37-44.

The optimal method developed in our laboratory for concentrating viruses from large volumes of sewage effluents involves four steps. These are: (1) removal of large particles from the effluents with clarifying filters; (2) adsorption of viruses in the clarified effluents to membrane filters at low pH; (3) elution of adsorbed viruses from the membranes with a buffer solution at high pH; and (4) reconcentration of the viruses into a small volume for assay.

Certain problems are associated with each of these steps. (a) When inorganic or organic gels are present in an effluent, viruses may be adsorbed on or trapped within them and be removed by the clarifying filters. (b) The membrane filters used for adsorption of viruses may clog. (c) Elution of adsorbed viruses requires high pH, but the elution time must be short to prevent inactivation of viruses. With clogged filters, the elution time is extended and some viruses may be inactivated. (d) The membrane filters adsorb organic compounds from water samples which may be eluted with the viruses. These organic compounds form flocs at low pH that clog the small filters used for reconcentration of viruses.

These problems can be resolved. Samples can be clarified at high pH with tetrasodium ethylenediaminoacetic acid so that viruses are not removed by clarifying filters. A melamine-epoxy-fiberglass membrane filter that resists clogging by water samples at low pH may be used. Eluates that cannot be reconcentrated on small diameter membranes because of organics eluted with the viruses from the clarifying filters and virus-adsorbing filters may be reconcentrated by an aluminum hydroxide gel technic.

γρ

Ward, R.L., Ashley, C.S. (1976). *Inactivation of Poliovirus in Digested Sludge.* **APPL ENVIRON MICROBIOL, 31(6)**:921-30.

Poliovirus, seeded into anaerobically digested sludge incubated at temperatures of 28 C and 4 C, was fully recovered from the sludge, but infectivity of the virus decreased in proportion to the time and temperature of incubation. The rate of inactivation of the virus ranged from greater than 90%/day at 28 C to about 90%/5 days at 4 C.

The RNA of inactivated virions appeared to have been damaged and had an average sedimentation value about 70% of that of RNA from infective polioviruses. Since the specific infectivity of RNA extracted from polioviruses recovered from sludge was directly proportional to that of the particles from which the RNA had been extracted, loss of infectivity was probably due to inactivation of RNA.

Some breakdown occurred also in the two largest proteins in the inactivated virions. Thus, inactivation of polioviruses in digested sludge may result from cleavage of viral proteins and subsequent damage to virion RNA.

Virucidal activity was not present in raw sludge; thus, the component of digested sludge responsible for inactivation of the poliovirus appears to be a product of the digestion process.

γ ρ

Ward, R.L., Ashley, C.S., Moseley, R.H. (1976). *Heat Inactivation of Poliovirus in Wastewater Sludge.* **APPL ENVIRON MICROBIOL, 32(3)**:339-46.

Raw sludge protected the plaque-forming ability of polioviruses 1 and 2. In low concentrations at relatively low temperatures, digested sludge protected polioviruses nearly as well as raw sludge did. At higher temperatures, the rate of inactivation of the polioviruses accelerated in digested sludge.

The difference in the protective capability of raw and digested sludges was not accounted for by loss of protective material in digested sludges. The protective component was present in the solids of digested sludges and in those of raw sludges. A virucidal agent was produced during digestion of sludges which when added to the solids of either raw or digested sludges reversed the protective potential of those solids during heat treatment of polioviruses

ξ θ

Waterson, A.P. (1976). *Infectious Particles in Hepatitis.* **ANN REV MED, 27**:23-25.

The etiological agents of hepatitis A and hepatitis B are reviewed in some detail.

λ τ ρ

Wellings, F.M., Lewis, A.L., Mountain, C.W. (1976). *Demonstration of Solids-Associated Virus in Wastewater and Sludge.* **APPL ENVIRON MICROBIOL, 31(3)**:354-8.

Many of the viruses in wastewaters, sludges, and soils, are solids-associated. In samples of sewage influent, effluent, and chlorinated effluent, from 16 to 100% of the total quantities of viruses recovered were solids-associated. By concentration with polyethylene glycol, viruses were recovered from the sonicated solids of fully digested sludges (60 days at 34 C), from sonicated

sand taken from the site of a sewer lead, and from sonicated dried sludge cake and mud collected 900 meters downstream from a sewage disposal site.

These data underscore the importance of processing solids as a part of any technic for recovering viruses from environmental waters.

To liberate viruses, sludges in elutant (3% beef extract) were sonicated (100 W for 15 minutes in a rosette cooling cell, Sonifier Model W 350, Ultrasonic, Inc.), stirred mechanically at 4 C for 18 hours, or extracted with fluorocarbon. The three methods produced equal recoveries.

ξ_λ

Wellings, F.M., Lewis, A.L., Mountain, C.W. *Viral Concentration Techniques for Field Sample Analysis.* **In "Virus Aspects of Applying Municipal Waste to Land," Symposium Proceedings, edited by L.B. Baldwin, J.M. Davidson, and J.F. Gerber. Center for Environmental Programs, University of Florida, Gainesville** (1976), 45-51.

No one virus concentration technic can be used effectively with all field samples. The membrane adsorption system appears to be the most promising technic for large samples of water, but viruses must be eluted not only from the virus adsorbing filters but from the clarifying filters used in the system also.

Al^{+++} must not be used in these systems when the waters that are processed contain large quantities of phosphates, because viruses bind irreversably to $AlPO_4$.

ξ_κ

Westwood, J.C.N., Sattar, S.A. *The Minimal Infective Dose.* **In "Viruses in Water," edited by G. Berg, H.L. Bodily, E.H. Lennette, J.L. Melnick, T.G. Metcalf. American Public Health Association, Washington, D.C.** (1976), 61-9.

Laboratory studies provide strong evidence that one virus particle can establish infection in a single cell in culture and in a mammalian host. Extreme dilution of viruses in the environment reduces the probability of infection of individuals in an exposed population, but does not eliminate it. Since many viruses are stable in the environment for long periods of time, the effect of viral pollution of water must be a low-grade seeding of the population with the production of endemic foci of infection in the community.

The real question to be answered is whether such endemic foci are of sufficient importance to the community to warrant major action.

ξ_π

WHO Expert Committee on Fish and Shellfish Hygiene, Committee Report. *Fish and Shellfish Hygiene.* **WHO Technical Report Series, FAO AND WHO, Geneva, Switzerland** (1974), 3-62.

The transmission of viral diseases to man by shellfish is discussed briefly within a broad review of fish and shellfish hygiene.

ξ

WHO Scientific Group on Virus Diseases. (1975-6). *The New Program of the World Health Organization in Medical Virology.* **INTERVIROL, 6(3)**:133-49.

The viruses that may be transmitted with water, especially the hepatitis viruses, the gastroenteritis viruses, and the enteroviruses, are discussed within an overall review of viral diseases.

ξ δ θ

Wiesmann, E. (1975). *Prophylaxis of Virus Hepatitis.* **GASTROENT FORTBILDUNGSK PRAX, 5**:141-8. **German.**

The waterborne transmission of hepatitis A is noted within a discussion of the viral hepatitites and their treatment.

ν

Zelepukha, S.I., Zemlerub, I.L., Zayakin, Z.R. (1975). *Removal of Microorganisms from Water by Contact Coagulation.* **MIKROBIOL ZH, 37(5)**:648-52. **Ukrainian.**

Staphylococcus aureus, Escherichia coli, and a coliphage were removed from water with equal effectiveness by coagulation with $FeCl_3$, $FeSO_4$, and $Al_2(SO_4)_3$ doses up to 40 to 50 mg/liter. $Fe_2(SO_4)_3$ was less effective. $Al_2(SO_4)_3$, unlike the other reagents, was easily *overdosed*, and this resulted in reduced removal of the microorganisms and the virus from the water.

The effectiveness of removal of the microbes decreased in the following order: *S. aureus, E. coli,* coliphage. The effectivness of removal of the *S. aureus* from the water was inversely related to its initial concentration.

λ μ

Zotova, V.I., Myshlaeva, L.A. (1976). *Quantitative Determination of Enteroviruses in Waters.* **GIG SANIT, 0(3)**:63-5. **Russian.**

Seeded poliovirus 1 was concentrated from sewage and from autoclaved river and tap water by adsorption of the virus onto AV-17 (an anion exchange resin) at pH 5 and elution of the virus from the resin with 0.5 M phosphate buffer at pH 8.2. The extent of adsorption of viruses onto the resin decreased with increased pollution of the water; 12% of the virus was adsorbed from sewage and 39% was adsorbed from tap water. The extent of adsorption of the virus was inversely related to the concentration of seeded virus.

With this anion exchange technic, 15 to 30 viruses/liter were recovered from river waters, 980 to 2,320 viruses/liter were recovered from mechanically and biologically treated sewages, and 100 to 350 viruses/liter was recovered from chlorinated effluents.

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